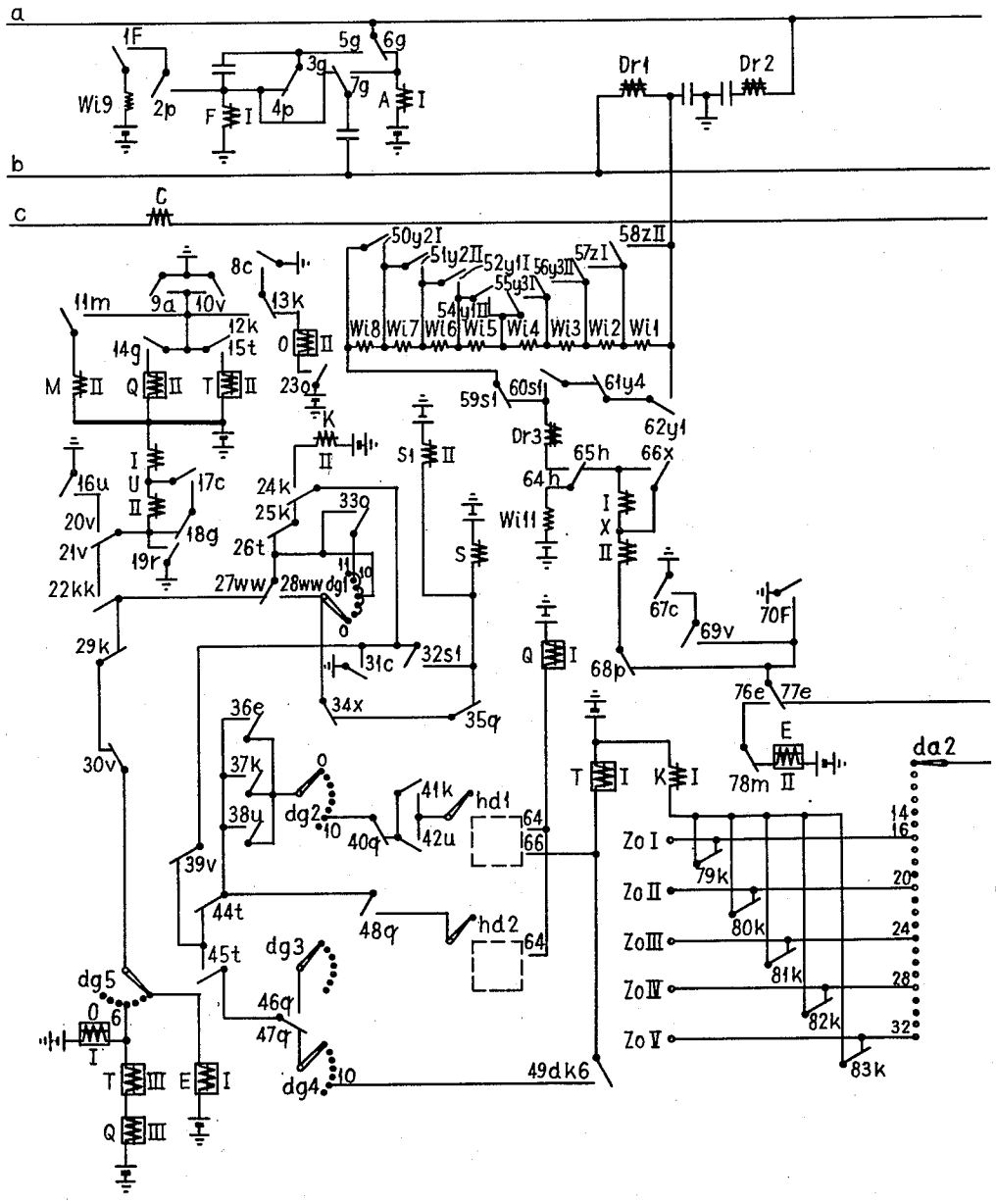
April 4, 1939. H. TÖPFER ET AL 2,153,319

AUTOMATIC TELEPHONE SYSTEM

Filed July 31, 1937 2 Sheets-Sheet 1

FIG. 1




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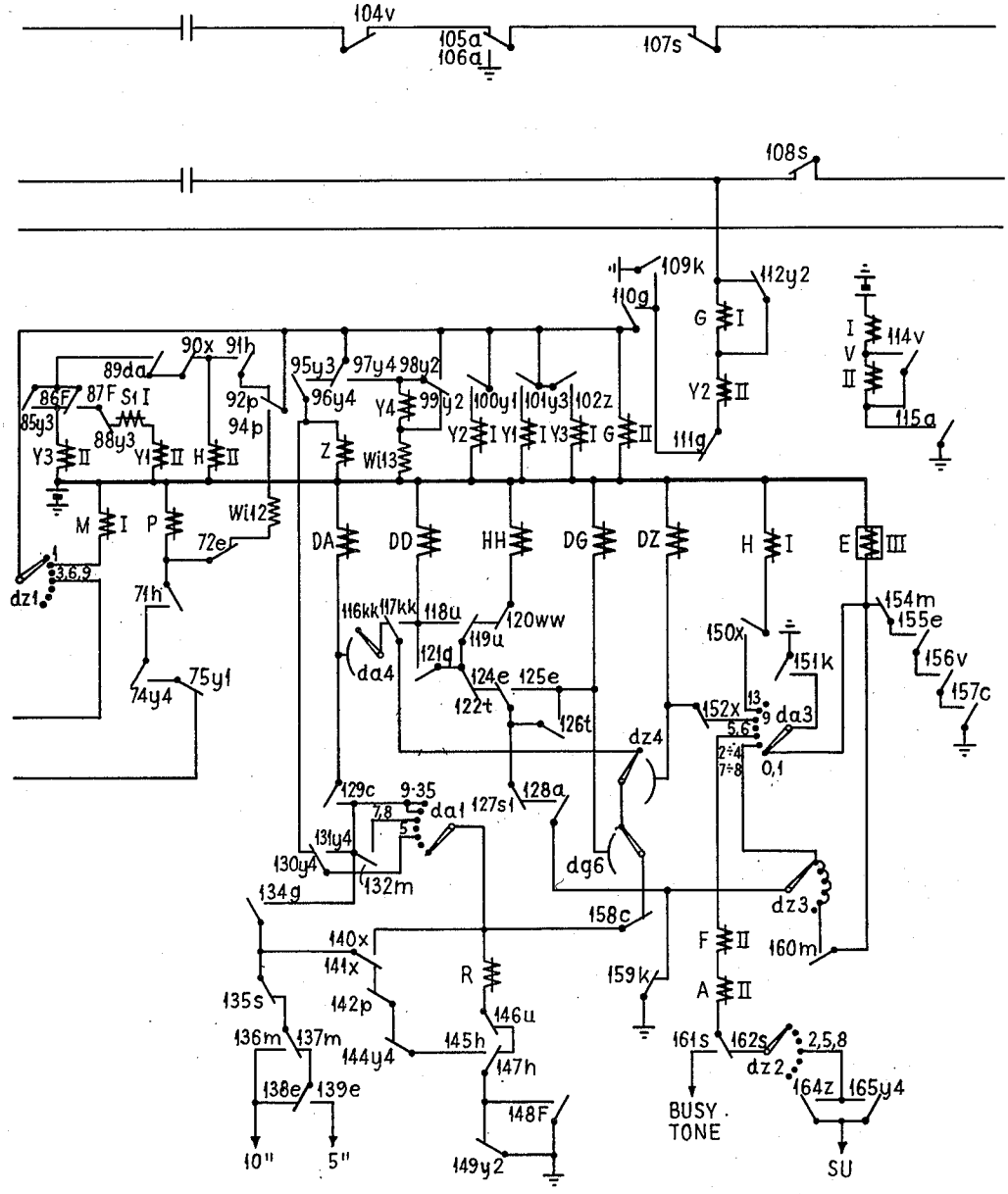
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FIG. 2




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# UNITED STATES PATENT OFFICE

2,153,319

## AUTOMATIC TELEPHONE SYSTEM

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In Germany August 4, 1936

8 Claims. (Cl. 179—7.1)

The present invention relates to a circuit arrangement for remote communication systems and more especially telephone systems in which metering impulses are transmitted over the speaking leads during the call.

If only the speaking leads are available for transmitting metering impulses in such systems, then if metering impulses are to be transmitted to the calling subscriber's meter while conversation is in progress devices must be provided to prevent the conversation of the subscribers engaged in the call, and also the devices influenced over the speaking leads, from being disturbed.

Arrangements are already known which, in order to meet this requirement, gradually build up the metering impulse by gradually connecting and disconnecting resistances and thereby gradually increasing or decreasing the current strength over one of the speaking leads. The result of this is that the metering impulses are transmitted in only a relatively slow succession. If it happens in such systems that further metering impulses are to be transmitted after the termination of the call i. e., at a time when the above-mentioned disturbances cannot arise it would be necessary to hold the connecting devices and lines seized for an unnecessarily long time and to withdraw them from general traffic on account of the slow transmission of metering impulses.

The present invention aims at achieving as rapid as possible a release of the connecting devices and lines in such cases and realizes this in that on the termination of the call, switching means associated with the meter advancing devices become operative, and cause the metering impulses still to be transmitted to be transmitted in a more rapid succession than when the call is in progress.

An embodiment of the invention is represented in the drawings comprising Figs. 1 and 2.

The main parts of the repeater shown are as follows:

(1) *Rotary switch DG.*—This rotary switch is set in a definite manner by the first numerical impulse train transmitted by the calling subscriber and operating on the repeater. According to the number of digits necessary for determining the zone of the call a wiper of this rotary switch is either directly connected to a zone contact or a wiper of a two-motion switch is connected up by a wiper of this rotary switch.

(2) *The two motion switch.*—The two-motion switch with its vertical magnet HH and its rotary magnet DD is set by the second and third impulse train operating on the repeater. In particular cases it takes up a fourth digit.

(3) *The time switch DZ.*—The time switch is influenced by a time switching device which operates so that it receives a stepping impulse every minute. The time switch determines in the present embodiment the moment for transmitting a definite number of metering impulses.

(4) *The assessor DA.*—The assessor is advanced by steps when the moment arrives for transmitting metering impulses, the stepping being continued until one of its wipers finds a zone contact characterized by a particular potential. On each step metering potential is applied over one of the speaking leads and in this way the calling subscriber's meter is advanced a definite amount. The assessor serves moreover to register the small units of time. It is under the influence of a five or ten seconds contact and registers these time impulses until a larger interval of time, namely, a minute, has elapsed. The minute units are then taken up by the time switch DZ as previously mentioned.

The mode of operation of the devices shown will now be described in detail.

*Setting the zone characterizing devices.*—The seizure of the repeater takes place over the c-lead in which is disposed relay C. Relay C is energized. Relay C closes contact **31***c* and thereby completes the following circuit: earth, contact **31***c*, **25***k*, **26***t*, **27***ww* (rotary off-normal contact operated when the two motion switch is in its operated position), **29***k* and **30***v*, wiper *dg***5** in the reset position, winding I of relay E, battery and earth. In this circuit relay E energizes and by closing its contact **125***e* connects the impulsing contact **128***a* to the magnet of the rotary switch DG. When now a numerical impulse train is transmitted by the calling station relay A is energized impulsively in the following circuit by the impulsive application of earth to the upper speaking lead in the preceding connecting device: earth in the preceding connecting device, upper speaking lead, contact **6***g*, winding I of relay A, battery and earth. Through the impulsive closing and opening of contacts **105***a* and **106***a* earth is connected to the upper speaking lead on each impulse so that impulses are transmitted to the subsequent connecting devices over contact **107***s* corresponding to the impulses received and these serve to set these connecting devices. Through the impulsive closing of contact **115***a* the following circuit is completed for relay V: earth, battery, windings I and II of relay V, contact **115***a* and earth. When it energizes for the first time,

relay V closes contact 114*v* and thus short-circuits its winding II. It is thereby made slow-to-release and this suffices to hold up the contacts of relay V during the individual impulse trains. The rotary switch DG is now set by the impulsive closing of contact 128*a*, the magnet being operated over the following circuit: earth, contacts 159*k*, 128*a*, 217*sl*, and 125*e*, the magnet of the rotary switch DG, battery and earth. The wipers of the switch DG are thus brought to a particular contact. Although wiper *dg*5 has left its rest position relay E remains operated throughout the impulse train in the following circuit: earth, contacts 157*c*, 156*v*, 155*e*, and 154*m*, winding III of relay E, battery and earth.

If the zone is determined merely by the first numerical impulse train operating on the repeater the wiper *dg*2 stands on one of the contacts 1 to 5, 7 to 9 which is connected directly to one of the zone contacts ZoI to ZoV. If in particular cases the zone is determined by two impulse trains operating on the repeater a further setting of the rotary switch takes place in accordance with the second impulse train received. The necessary requirement for this is that the first impulse train shall have brought the wipers of the rotary switch into position 6. After relay V has released on account of the prolonged opening of contact 115*a* after the impulse train comprising six impulses the following circuit is established over wiper *dg*5; earth, contacts 31*c*, 25*k*, 26*t*, 27*ww*, 29*k* and 30*v*, wiper *dg*5 in position 6, windings III of relays T and Q, battery and earth, and winding I of relay O, battery and earth. After the first impulse train the locking circuit for winding III of relay E is broken by the opening of contact 156*v* so that relay E releases. Since, however, relay T has been energized in the circuit just described the impulse train which now follows is transmitted to the magnet of the rotary switch DG over contact 126*t*, while an undesired setting of the vertical magnet HH of the two-motion switch which was connected up when contact 124*e* closed is prevented by the opening of contact 122*t*. The second impulse train is thus transmitted to the magnet of the rotary switch DG over the following path: earth, contacts 159*k* 128*a*, 127*sl* and 126*t*, the magnet of the rotary switch DG, battery and earth. At the end of this impulse train relay T releases again, this being a slow-release on account of the construction of the relay. Relay Q also remains up until after the end of the impulse train and also until the end of its natural release period, over the circuit: earth, contact 9*a* or 10*v*, 14*q*, winding II of relay Q, battery and earth. Wiper *dg*2 is disconnected by contact 44*t* and wiper *dg*3 is connected up through the closing of contacts 45*t* and 46*q*. The zone contact is thus reached in the present case over wiper *dg*3 whose contacts are connected to the zone contacts ZoI to ZoV in a particular manner.

If the zone is not to be determined until the third impulse train operating on the repeater has been transmitted, the rotary switch DG is brought to position 0 by the first impulse train operating upon it, i. e., the impulse train comprises ten impulses. In this case relays T and Q cannot energize. As already mentioned relay E releases a short time after the termination of the first impulse train (through the opening of contact 156*v*). Contact 125*e* is thereby opened and the magnet of the rotary switch DG is disconnected and the vertical magnet HH of the two-motion switch is connected up by the closing of contact 124*e*. The second impulse train operating on the repeater is thus repeated to the vertical magnet HH over the following circuit: earth, contacts 150*k*, 128*a*, 127*sl*, 124*e*, 122*t*, 119*u*, 120*ww* (off-normal contact which is opened after the first rotary step of the two-motion switch) vertical magnet HH, battery and earth. The wipers of the two-motion switch, of which only the two wipers *hd*1 and *hd*2 are shown, are thus raised to a particular level. The contact field of the two-motion switch is indicated by dotted squares adjacent the wipers *hd*1 and *hd*2 for the sake of simplicity. Since the off-normal contact 22*kk* is closed after the first vertical step of the two-motion switch the following circuit is set up when relay V releases: earth, battery, winding I of relay U, contacts 17*c*, 18*g*, 21*v*, 22*kk*, 27*ww*, (rotary off-normal contact of the two-motion switch opened after the latter has taken the first rotary step), 26*t*, 25*k*, 31*c*, and earth. In this circuit relay U energizes. When now the third impulse train is received relay V is energized throughout this impulse train. Consequently contact 20*v* is closed thereby completing a locking circuit for relay U: earth, contacts 16*u*, 20*v*, 18*g* and 17*c*, winding I of relay U, battery and earth. During this impulse train, contact 119*u* is opened so that the vertical magnet HH is disconnected and contact 118*u* is closed thereby switching in the rotary magnet DD of the two-motion switch. The third impulse train operating on the repeater accordingly operates the rotary magnet of the two-motion switch this taking place over the following circuit: earth, contacts 159*k*, 128*a*, 124*e*, 122*t* and 118*u*, rotary magnet DD, battery and earth. In the level to which the switch has been set the wipers are accordingly brought to a particular contact. On the termination of the impulse train relay V releases and release relay U by opening contact 20*v*. The contacts of the two-motion switch are wired to the zone contacts ZoI to ZoV in a particular way.

According to the embodiment it is also possible to determine the zone only after four impulse trains have operated on the repeater. If for example, the first impulse train operating on the repeater comprises ten impulse, wiper *dg*2 is brought to position 10. If then the two-motion switch is stepped to the sixth level and then set on the fourth contact in the sixth level the wipers *hd*1, *hd*2 stand on a line characterized by the number "64". After relay V releases after the third impulse train operating on the repeater the following circuit is completed: earth, battery, winding I of relay Q, line 64, wiper *hd*1, contact 42*u*, (relay U remains up after relay V has released because it is made slow-to-release to a certain extent through the short-circuiting of its winding II), contact 40*q*, contact 10, wiper *dg*2, contacts 38*u*, 44*t*, 39*v*, 31*c* and earth. Relay Q opens its contact 40*q*, breaks the circuit just mentioned and closes contact 48*q*, whereby the following locking circuit is established for relay Q independently of the contacts of relay U, over wiper *hd*2: earth, battery, winding I of relay Q, line 64, wiper *hd*2, contacts 48*q*, 44*t*, 39*v* and 31*c* and earth. Relay Q closes its contact 121*q* whereby the next impulse train is also transmitted to the rotary magnet DD of the two-motion switch in spite of contact 118*u* being open: earth, contacts 159*k*, 128*a*, 127*sl*, 124*e*, 122*t* and 121*q*, magnet DD of the two-motion switch, battery and earth. During this impulse train relay Q holds up over its winding II in a

circuit which has already been set out. The characterization of the zone (setting on a particular zone contact) now takes place over wiper *hd2* of the two-motion switch whose contacts are connected to the zone contacts ZoI to ZoV in a particular way.

The characterization of the zone by four impulse trains operating on the repeater can be effected in an alternative manner. If, for example, impulse trains corresponding to the number "066" are sent in to the repeater, wiper *hd1* of the two-motion switch will stand on line **66** so that after the release of relay U and during the release period of relay U the following circuit is closed: earth, battery, winding I of relay T, line **66**, wiper *hd1*, contacts **42***u*, and **40***q*, wiper *dg2*, contacts **38***u*, **44***t*, **39***v* and **31***c* and earth. In this circuit relay T energizes and by opening its contact **44***t* disconnects wipers *hd1* and *hd2* of the two-motion switch and by closing contact **45***t* connects wiper *dg4* of the rotary switch DG. The following locking circuit is establishes for relay T: earth, battery, winding I of relay T, level contact **49***dk***6** (closed when the two-motion switch is set on lever **6**), contact **10**, wiper *dg4*, contacts **47***q*, **45***t*, **39***v*, and **31***c* and earth. During the impulse train which now follows relay T holds up over its winding II in a circuit which has previously been described. The fourth impulse train received by the repeater is now also taken up by the rotary switch DG whose magnet is operated by contact **126***t*; earth, contacts **159***k*, **128***a*, **127***s***1**, and **126***t*, the magnet of the rotary switch DG, battery and earth. The characterizing of the zone now takes place over wiper *dg4* of the rotary switch DG over a contact of the latter which is directly connected to one of the zone contacts ZoI to ZoV.

*Zone control*

For each of the numerical impulse trains operating on the repeater the zone control sets in automatically i. e., switching operations are promoted whereby testing takes place after each impulse train has been transmitted as to whether the zone has already been characterized, and any influencing of the zone characterizing devices by further numerical impulse trains is prevented. The particular device executing this zone control is the zone control relay K.

(*a*) *Zone control after the first impulse train operating on the repeater*

The rotary switch DG is set so that its wipers do not rest on contact **6** or **10**. By the setting of the rotary switch DG in accordance with another digit of the zone is characterized solely by this first impulse train operating on the repeater. After the release of relay V the following circuit for relay K is set up: earth, battery, winding I of relay K, one of the contacts **79***k*, **80***k*, **81***k*, **82***k* or **83***k*, one of the zone contacts ZoI to ZoV, wiper *dg2*, in a position other than 6 or 10, contacts **36***e*, **44***t*, **39***v*, and **31***c* and earth. Relay K energizes and by opening its contact **159***k* brings the influencing of the zone determining devices by numerical impulse trains to an end.

Relay K locks up over the following circuit throughout the duration of the call: earth, battery, winding II of relay K, contacts **24***k* and **31***c* and earth. Contact **37***k* maintains the earth connected over contact **31***c* connected to wiper *dg2* and the corresponding zone contact.

It may be mentioned that relay X is energized over the following circuit during each impulse train: earth, contacts **67***c*, **69***v* and **68***p*, windings II and I of relay X, contact **65***h*, resistance **Wi1**, battery and earth. Relay X closes its contact **66***x* and thereby short-circuits its winding I so that after relay V has released and contact **69***v* has opened it retains its contacts in the operated position for a short time. After the release of relay V and the closing of contact **39***v* it is possible for relay K to energize. If, however, this is not possible on account of the presence of a fault in the zone lead relay S energizes after relay X has released, in the following circuit: earth, battery, the winding of relay S, contacts **35***q* and **34***x*, wiper *dg1* in a position other than 0, 6 or 10, contacts **26***t*, **25***k* and **31***c* and earth. If, therefore, the zone circuit control cannot be exerted in a positive sense relay S energizes and by opening its contacts **107***s* and **108***s* disconnects the stepping leads and renders the further setting of connecting devices impossible. Relay S1 also energizes and at contact **127***s***1** disconnects contact **128***a*. Through the closing of contact **161***s* a busy signal is applied to windings II of relays A and F and is induced in the windings I of these relays which are connected to the speaking leads and is thus transmitted to the calling subscriber. Winding I of relay F is connected over contact **3***g* and a condenser to the lower speaking lead and winding I of the relay A to the upper speaking lead over contact **6***g*. The relays S and S1 hold up in the circuit set out above until the calling subscriber replaces his receiver on account of the prolonged busy signal and transmits the signal for the release of the devices which have been set.

(*b*) *Zone control after two impulse trains have operated on the repeater*

In this case the calling subscriber transmits an impulse train corresponding to the number "6" as the first impulse train. Wiper *dg5* is thus set on contact **6**, over which relays T and Q are energized over their windings III and relay O over its winding I after relay V has released. After this impulse train relay K cannot yet energize because contact **6** of the rotary switch is not connected to any of the zone contacts ZoI to ZoV. Similarly the blocking relay S cannot energize because this is disconnected by contact **35***q*. Thus although the zone control relay K cannot energize after the first impulse train the blocking of the connection by relay S is also prevented. Only when the rotary switch DG has received a further impulse train is the following circuit set up for relay K: earth, battery winding I of relay K, one of the contacts **79***k* to **83***k*, one of the zone contacts ZoI to ZoV, a contact in the contact bank associated with wiper *dg3*, wiper *dg3*, contacts **46***q*, **45***t*, **39***v* and **31***c* and earth. When relay K energizes in this circuit, contact **12***k* and the two relays Q and T remain energized in the following circuit until the end of the call: earth, contacts **8***c*, **12***k* and **14***q*, winding II of relay Q— and contact **15***t*, winding II of relay T, battery and earth. After relay K has energized and locked up at contact **24***k* a particular zone contact is connected to earth other contact **31***c* by way of wiper *dg3* and contacts **45***t* and **46***q*.

If, however, relay K is not able to energize in the above circuit on account of a break in the zone lead or because a false second number has been dialled whereby wiper *dg3* is set on a contact which is not connected to a zone contact, no locking circuit is set up for relays Q and T so that after relay X has released the following circuit is

established for the blocking relay S: earth, battery, the winding of relay S, contacts 35*q* and 34*x*, wiper *dg*1, contacts 26*t*, 25*k* and 31*c* and earth. Relay S1 also energizes over winding II and at contact 127*s*1 disconnects the impulse contact 128*a*.

If the calling subscriber dials an impulse train corresponding to the number "4" the above circuit for the blocking relay S cannot be established when relay K does not energize since contact 10, to which wiper *dg*1 is then set, is not connected to the other contacts of this contact bank. As already described relay O was energized over its winding I when wiper *dg*5 was set on contact 6. Relay O locks up in the following circuit: earth, contacts 8*c* and 13*k*, winding II of relay O, contact 23*o*, battery and earth. This locking circuit remains in existence until the clearing signal is given if the zone controlling relay K cannot energize. In this case the following circuit is closed for the blocking relay S: earth, battery, winding of relay S, contacts 35*q* and 34*x*, wiper *dg*1 in position 10, contacts 33*o*, 26*t* and 25*k*, 31*c* and earth.

*(c) Zone control after the third impulse train operating on the repeater*

After the rotary switch DG has been set on the 10th contact the wipers of the two-motion switch stand on some line which is not especially indicated (but not on lines 64 and 66) after the next two impulse trains. After relay V has released at the end of the third impulse train operating on the repeater, the circuit for the zone control relay K is set up over wiper *hd*1 and wiper *dg*2 in position 10, the circuit being set up over contact 38*u* of relay U which maintains its contacts operated after the release of relay V. Relay K locks up as before at contact 24*k* throughout the duration of the call and at contacts 37*k* and 41*k* maintains the connection of earth to the corresponding zone contact.

If for the reasons mentioned above the circuit for relay K is not completed the blocking relay S and relay S1 become energized in the following circuit after relay X has released: earth, battery, the winding of relay S and S1, contacts 35*q*, 34*x* and 28*ww* (rotary off-normal contact of the two-motion switch which is closed when the switch takes its first rotary step) contacts 26*t*, 25*k* and 31*c* and earth. Relay S initiates the operations already described for preventing the further establishment of the call and for communicating a busy signal to the calling subscriber, while relay S1 prevents the zone characterizing devices from being influenced by further numerical impulse trains at contact 127*s*1.

*(d) Zone control after the fourth impulse train operating on the repeater*

If the two-motion switch is set on line 64 relay Q is energized as already stated and this disconnects wiper *hd*1 of the two-motion switch at contact 40*q* and connects up wiper *hd*2 by closing contact 48*q*. During the fourth impulse train operating on the repeater, which is also received by the rotary magnet DD, of the two-motion switch, relay Q remains operated over its winding II for some time after relay V has released at the end of the fourth impulse train. Thus the wipers of the two-motion switch stand on a particular line (not shown) which is connected to one of the zone contacts ZoI to ZoV. During the release period of relay Q the zone control relay K is tested as to its ability to energize, in the following circuit: earth, battery, winding I of relay K one of the contacts 79*k* to 83*k*, one of the zone contacts ZaI to XoV, wiper *hd*2 of the two-motion switch, contacts 48*q*, 44*t*, 39*v* and 31*c* and earth. The blocking relay S is not able to energize because contact 25*k* is open. If, however, relay K does not energize within the release period of relays Q and X a circuit which may be seen from the drawing is once more set up for the blocking relay S.

If the two-motion switch is brought by the third impulse train operating on the repeater to line 66, relay T, is operated as already explained and this holds up over its winding II during the following fourth impulse train until the end of this train, when relay V releases. At contact 44*t* the wipers of the two-motion switch are disconnected and wiper *dg*4 of the rotary switch DG is connected up at contact 5*t*. The wipers of the rotary switch DG are stepped further by the fourth impulse train, so that wiper *dg*4 is set on a contact which is connected to one of the zone contacts ZoI to ZoV. When relay V releases at the end of the fourth impulse train the zone control relay K is tested as to its ability to energize on the following circuit: earth, battery, winding I of relay K, one of the contacts 79*k* to 83*k*, one of the zone contacts XoI to ZoV, wiper *dg*4 set on a particular contact, contacts 47*q*, 45*t*, 39*v*, and 31*c* and earth. If relay K cannot energize during the release period of relay X, the circuit for the blocking relay S and for relay S1 is again closed.

*The wanted subscriber replies*

When the wanted party replies after all the impulse trains have been transmitted, in which connection it should be noted that the upper speaking lead is broken by the opening of contact 104*v* during each impulse train in order to prevent the calling subscriber being disturbed, battery potential is applied to the lower speaking lead in one of the succeeding connecting devices. Thus the following circuit is established: earth, battery in the succeeding device, the lower speaking lead, contacts 108*s*, and 112*y*2, winding II of relay Y2, contacts 111*g* and 109*k* and earth. Relay Y2, which energized in this circuit at contact 112*y*2, breaks the previously existing short-circuit for winding I of relay G so that this relay can energize in the above-mentioned circuit. Relay G closes its contacts 110*g* and thereby locks up over earth, contacts 109*k*, and 110*g*, winding II of relay G, battery and earth. Through the opening of contact 111*g* it breaks the above-mentioned circuit. Through the closing of contact 134*g* the following circuit is closed for the switch DA which responds to the small units of time of five or ten seconds: earth, battery, the magnet of switch DA, contacts 129*c*, 134*g*, 135*s*, 137*m*, and 139*e*, the five-seconds contact and earth. Relay E was operated over its winding III in the following circuit: earth, contact 151*k*, wiper *da*3 of the assessor in positions 0—1, winding III of relay E, battery and earth. The assessor consequently receives five seconds impulses and steps its wipers at intervals of five seconds. When wiper *da*3 has left contacts 0 and 1 relay E releases and by closing its contact 138*e* switches on a 10 seconds contact in place of the five seconds contact so that now the assessor is advanced at intervals of 10 seconds. When after the expiration of about a minute the wipers of the assessor reach contact 9 the assessor commences to pass automatically to the zero position. This occurs in the following manner: when wiper *da*1 reaches the ninth contact the following circuit is completed: earth, battery,

magnet DA of the assessor, contact 129c, contact 9, wiper da1, the winding of relay R, contacts 146u, 147h, 149y2 and earth. Relay R which energizes in this circuit closes its contact 19r and this completes the following circuit for relay U: earth, contact 19r, windings II and I of relay U, battery and earth. By the opening of contact 146u, the above circuit in which magnet DA and relay R were energized is broken. The assessor magnet DA and also relay R release, so that the circuit for relay U at contact 19r is broken again. Magnet DA and relay R are again operated by the closing of contact 146u. The interaction between relays U and R continues until wiper da1 has left its last contact 35 and has passed into the rest position. The following circuit for the magnet DZ was closed over wiper da3 in position 9: earth, contact 151k, da3, position 9, contact 152x, magnet DZ of the time switch, battery and earth. The time switch accordingly advances its wipers from the rest position to the first contact. The following circuit then obtains for relay M: earth, battery, winding I of relay M, contact 1, wiper dz1 of the time switch, contacts 110g and 109k and earth. Relay M holds up throughout the duration of the call in the following locking circuit: earth, battery, winding II of relay M, contacts 11m, 12k and 8c and earth. When the circuit already mentioned for winding III of relay E is closed again when wiper da3 moves into the rest position the 10 seconds contact remains connected to the assessor magnet because of the closed contact 136m. When now after expiry of the second minute the wipers of the assessor pass to position 7 the play between relays R and U sets in once more, relay R being energized together with the assessor magnet in the following circuit: earth, contacts 149y2, 147h, and 146u, the winding of relay R, wiper da1 in position 7, contacts 132m and 129c, magnet DA of the assessor, battery and earth. The assessor is thus switched back to its normal position. On passing through position 9 the circuit previously mentioned for the time switch DZ was again closed so that the wipers of the time switch are set at contact 2. The third minute of the conversation now commences. When the switch passes to position 5 under the influence of the 10 seconds contact relay Z energizes in the following circuit: earth, battery, the winding of relay Z, contact 130y4, contact 5, wiper da1, the winding of relay R, contacts 146u, 147h and 149y2 and earth. Relay Z closes its contact 102z and thereby completes the following circuit for relay Y3: earth, contacts 109k, 110g, and 102z, winding II of relay Y3, battery and earth. Relay Y3 closes its contact 101y3 and thereby completes the following circuit for relay Y1: earth, contacts 109k, 110g, 101y3, winding I of relay Y1, battery and earth. Relay Y1 causes relay Y2 to energize over its winding I by closing contact 100y1. This latter relay by closing its contact 98y2 switches on relay Y4 over earth, contacts 109k, 110g and 98y2, the winding of relay Y4, resistance Wi13, battery and earth. The opening of contacts 130y4 and 96y4 disconnects the circuit of relay Z. Relay Z at contact 102z opens Y3. Contact 101y3 breaks the circuit for relay Y1. Relay Y1 disconnects the circuit of relay Y at contact 100y1 so that the latter relay deenergizes. Relay Y2 closes its contact 99y2 and thereby short-circuits the winding of relay Y4 so that in spite of its locking contact 97y4, relay Y4 is caused to deenergize. For the period between the operation of relay Z and the release of relay Y4 a warning signal is transmitted to the calling subscriber shortly before the expiry of the third minute of the conversation, in that the following circuit is established: buzzer Su, contact 164z or 165y4, wiper dz2 set on contact 2, contact 162s, winding II of relays A and F, wiper da3 in one of the positions 5 and 6, contact 151k and earth. The buzzer tone is transmitted inductively to windings I of relays F and A in the speaking leads and hence to the calling subscriber. Winding I of relay A is now connected over contacts 7g and a condenser to the lower speaking lead and winding I of relay F to the upper speaking lead over a condenser and contact 5g. During the release period of relay Y4 which was short-circuited after the release of relay Y2 the assessor is advanced from position 5 to position 6: earth, battery, magnet DA of the assessor, contacts 129c, and 131y4, wiper da1 in position 5, the winding of relay R (which does not energize in this circuit) contacts 146u, 147h, and 149y2 and earth. After a further 10 seconds the wipers of the assessor are brought to contact 7 from which they are advanced to the zero position by the aid of the relay interrupter R/U in the manner already described. When wiper da3 passes through position 9 the circuit for the time switching magnet DZ is again closed so that the wipers of the time switch pass to position 3. The following circuit for relay X is now completed over wiper dz1 of the time switch: earth, contacts 109k and 110g, wiper dz in position 3, contacts 77e and 68p, windings II and I of relay X, contact 65h, resistance Wi11, battery and earth. When the assessor moves into position 13 the following circuit is set up for relay H: earth, battery, winding I of relay H, contact 150x, wiper da3 of the assessor in position 13, contact 151k and earth. Relay H locks up over earth, battery, winding II of relay H, contacts 91h, 92p, 110g and 109k and earth. Relay H opens contacts 65h and thus breaks the circuit just described for relay X which accordingly releases.

*Metering for the first unit of time*

Through the closing of contact 64h a metering potential is applied to the lower speaking lead over a series of resistance and choke-coils: earth, battery, resistance Wi11, contact 64h, choke-coil Dr3, contact 59s1, resistances Wi8, Wi7, Wi6, Wi5, Wi4, Wi3, Wi2 and Wi1, choke-coil Dr1, lower speaking lead. On account of the various resistances and the choke-coils the application of the metering potential by contact 64h to the lower speaking lead is damped so that the subscriber engaged in conversation is disturbed as little as possible. Through the closing of contact 145h the assessor magnet DA receives a stepping impulse over the following path: earth, battery, assessor magnet DA, contacts 129c, 134g, 141x, 142p, 144y4, 145h, 149y2 and earth. The assessor magnet possesses a contact 89da which is now closed and by means of which the following circuit is established: earth, battery, winding II of relay Y3, contacts 86f, 89da, 90x, 91h, 92p, 110g, 109k and earth. Relay Y3 at contact 95y3 switches on relay Z and at contact 101y3 switches on relay Y1. The circuits are as follows: earth, contacts 109x, 110g, and 101y3, winding I of relay Y1, battery and earth, and: earth, contacts 109k, 110g, 96y4, 95y3, the winding of relay Z, battery and earth. By closing its contact 100y1 relay Y1 energizes relay Y2. By the closing of contact 98y2 relay Y4 is energized and thus locks up by closing contact 97y4. Through the opening of contact 96y4 the above-mentioned circuit for relay Z is broken and this consequently releases. After relay Z relay Y3 releases, the winding II of this relay having

been disconnected meanwhile at contact 89*da*. After relay Y3 relay Y1 releases, after relay Y1 relay Y2, and after relay Y2 relay Y4, all being short-circuited.

The above-mentioned operations are now repeated because the circuit for the assessor magnet DA which was opened at contact 144*y*4 when relay Y4 energized is completed again at this contact after relay Y4 has released. The assessor magnet is advanced a further step and by closing its contact 89*da* causes the switching on of relays Y3Z, Y1, Y2 and Y4 in the manner described above.

Each time these relays perform this set of operations a metering impulse passes over the lower speaking lead to the metering relay in the preceding connecting device in that the individual resistances W*i*1 to W*i*8 are short-circuited in succession by the contacts of the above mentioned relays and on the subsequent release of the relays are switched in again in the succession W*i*1 to W*i*8. Each of the said relays possesses contacts which draw up and release at moments displaced from one another in time so that for example contact 50*y*2 is closed before contacts 51*y*2, 52*y*1 before 54*y*1, 55*y*3 before 56*y*3, and 57*z* before 58*z*. Thus the above-mentioned contacts are closed in succession and in this way the metering potential connected to the lower speaking lead is gradually increased to an extent which suffices to energize the metering relay connected to the lower speaking lead in the preceding connecting device. On the subsequent release of these relays at the end of each metering impulse the resistances W*i*1 to W*i*8 are gradually switched in and the current over the lower speaking lead is gradually reduced again so that the metering relay in the preceding connecting device can release. On account of the gradual switching in and switching out of the resistances and by the gradual application and disconnection of metering battery subscribers engaged in conversation are disturbed as little as possible. For each step of the assessor one metering impulse is transmitted over the lower speaking lead. The number of metering impulses to be transmitted at the end of every three minutes interval is determined by the setting of the zone characterizing devices, i. e., by the setting of the rotary switch DG and of the two-motion switch HH/DD. Over the wipers of these switches a particular zone contact ZoI to ZoV is connected to earth as previously described. As has been mentioned, relay H, which determines the moment for commencing metering, is energized when wiper *da*3 passes through position 13. The transmission of metering impulses accordingly only commences when the wipers of the assessor have reached contact 14. If, for example, the zone characterizing devices connect the zone ZoI to earth, as many metering impulses are transmitted as there are steps necessary in order to bring wiper *da*2 from position 14 to that position to which the zone contact ZoI is connected. In the example shown this would be two impulses. After the transmission of two metering impulses the following circuit obtains during the release period of relay Y4 which is the last of the relay chain to deenergize: earth on zone contact ZoI applied by the zone characterizing devices, wiper *da*2 on contact 16 contacts 75*y*1, 74*y* and 71*h*, the winding of relay P, battery and earth. Relay P at contact 142*p* breaks the stepping circuit for the assessor magnet DA which was closed during the transmission of metering impulses. At contact 94*p* it locks up over earth, battery, the winding of relay P, contact 72*e*, resistance W*i*12, contacts 94*p*, 100*g* and 109*k* and earth. By the opening of contact 92*p* the above-mentioned locking circuit for relay H which determines the commencement of metering is broken so that this relay releases. The result of this is that contact 147*h* is closed and consequently a circuit is completed which circuit contains the relay R and the assessor magnet DA. The interaction of relays R and U by means of which the assessor is restored to normal now sets in once more. When the assessor has reached its normal position relay E is operated again over winding 3 and by opening contact 72*e* breaks the locking circuit for relay P and thus causes this to release. This terminates the metering for the first three minute interval. Under the influence of the ten second switch the assessor magnet DA is now stepped round again and the second three minutes interval commences, and after the expiry of six minutes the second transmission of two metering impulses takes place in the manner described.

It may be mentioned that after the lapse of each interval of three minutes, i. e., when the wipers of the time switch DZ are set in positions 3, 6, 9, etc., relay E is held energized over its winding 3 during the following time unit of one minute. So long as wiper *da*3 stands on contacts 0 and 1 relay E is energized in a circuit which has been mentioned earlier. In positions 2 to 4 of the assessor DA, E is energized as follows: earth, contacts 151*k*, wiper *da*3 on contact 2, 3 or 4 over contacts 0, 3, 6, 9, 12 of the bank associated with wiper *dz*3, contact 160*m*, winding III of relay E, battery and earth. In positions 5 and 6 of wiper *da*3 relay E is held energized over the following circuit: earth, contact 151*k*, wiper *da*3 on contact 5 or 6, wiper *dz*3 on one of the contacts 3, 6, 9, etc., contact 160*m*, winding III of relay E, battery and earth. By this means so long as wiper *dz*1 stands on one of the contacts 3, 6, 9, etc., any undesired operation of relay X at contact 77*e* and any consequent premature energizing of the relay H which promotes metering at contact 150*x* is prevented.

It can be seen directly from the drawings that if another zone contact is connected to earth over the zone characterizing devices, a different number of metering impulses is transmitted. If, for example, the zone contact ZoII were connected to earth then six metering impulses would be transmitted after each three minute interval in the case of such a call. If the zone contact ZoIII were connected up ten metering impulses would be transmitted, in the case of zone contact ZoIV, 14, and in the case of zone contact ZoV, 18 impulses for every three minute interval.

*Metering at the end of the call*

When the calling subscriber hangs up on finishing his conversation, battery potential is applied to the upper speaking lead in the preceding connecting device so that the following circuit is set up for relay F in the repeater: earth, battery in the preceding connecting device, upper speaking lead, contacts 5*g*, 4*p*, winding I of relay F and earth. Relay F closes its contact 70*f* and thereby completes the following circuit for relay X: earth, contacts 70*f*, 68*p*, windings II and I of relay X, contacts 65*h*, resistance W*i*11, battery and earth. Relay X closes its contact 140*x* and thereby brings the assessor magnet DA under the influence of the relay interrupter. With the aid of relays R and U the assessor is advanced until, in position 13 a circuit, which has already been given, for

relay H is set up over wiper *da*3. Relay H locks up at contact 91*h* and by opening contact 147*h* interrupts the interaction between relays U and R. The assessor magnet DA receives a stepping impulse over the following path through the closing of contact 145*h*, earth, contacts 149*y*2, 145*h*, 144*y*4, 142*p*, 141*x* (relay X was deenergized by relay H at contact 65*h*), 134*g*, 129*c*, assessor magnet DA, battery and earth. The assessor magnet operates its contact 89*da* so that the following circuit is set up: earth, battery, winding II of relay Y1, winding I of relay S1, contacts 88*y*3, 87*f*, 89*da*, 90*x*, 91*h*, 92*p*, 110*g*, 109*k* and earth. In this circuit relays Y1 and S1 energize. Relay S1 locks up over: earth, battery, winding II of relay S1, contacts 32*s*1, 31*c*, and earth. Through the opening of contact 59*s*1 the resistance chain Wi1–Wi8 is disconnected and by the closing of contact 60*s*1 the full strength of the metering battery is applied directly, while eliminating the resistance chain, to the lower speaking lead: earth, battery, resistance Wi11, contact 64*h*, choke-coil Dr3, contacts 60*s*1, 61*y*4, and 62*y*1, choke-coil Dr1, and the lower speaking lead so that the metering relay in the preceding connecting device will immediately energize and cause the meter to be advanced. Relay Y1 closes contact 100*y*1 thereby switching on winding I of relay L2. At contact 98*y*2 relay Y2 switches on relay Y4 which locks up by closing contact 97*y*4. Relay Y4 opens contact 144*y*4 and thereby breaks the circuit for the assessor magnet DA. By the opening of contact 89*da* the circuit over which relays Y1 and S1 were energized is broken so that relay Y releases. Relay S1 holds up over its winding II. At contact 100*y*1 relay Y1 breaks the circuit for relay Y2 so that contact 99*y*2 is closed and relay Y4 is short-circuited. The stepping circuit for the assessor magnet is thus closed again at contact 144*y*4 so that the cycle of operations is started afresh. During each cycle the metering impulse is started by the closing of contact 62*y*1 and terminated by the opening of contact 61*y*4. In this way a corresponding number of impulses is transmitted at a relatively more rapid rate. Thus on metering at the end of the call only the relays Y1, Y2, and Y4 of the group Z, Y1–Y4 are used. The transmission of metering impulses is terminated when wiper *da*2 passes into a position which is connected to earth over one of the zone contacts ZoI to ZoV and over the zone characterizing devices, as has already been explained in detail. The metering terminating relay P disconnects earth from the upper speaking lead by opening its contact 4*p*, this being the signal that the preceding connecting device is released. Relay F in the repeater continues to hold up for the moment in a local circuit: earth, battery, resistance Wi9, contacts 1*f*, and 2*p*, winding I of relay F, and earth. Relay F holds up until relay P releases after the end of the metering and when the repeater is released. Through the disconnection of earth from the upper speaking lead the *c*-lead in the preceding connecting device is broken so that the relay C in the repeater releases.

*Restoration of the switches in the repeater*

After the release of relay C and the closing of contact 158*c* the following circuit is completed: earth, contacts 149*y*2, 147*h*, 146*u*, winding of relay R, contact 158*c*, wiper *dg*6 in the working position, magnet DG of the rotary switch, battery and earth. In this circuit in addition to magnet DG relay R also energizes so that through the interaction between relays R and U the wipers of the rotary switch are stepped until the rest position is reached.

The time switch is then brought to normal. The following circuit obtains: earth, contacts 149*y*2, 147*h*, 146*u*, winding of relay R, contact 158*c*, wiper *dg*6 in the rest position, wiper *dz*4 in the working position, magnet DZ of the time switch, battery and earth. The time switch is stepped by the relay interrupter RU until it has reached the normal position. Thereupon the two-motion switch is restored to normal. The following circuit obtains: earth, contacts 149*y*2, 147*h*, and 146*u*, winding of relay R, contact 158*c*, wiper *dg*6, in the rest position, wiper *dz*4 in the rest position, off-normal contact 117*kk* (closed after the first vertical step of the two-motion switch), rotary magnet DD of the two-motion switch, battery and earth.

The rotary magnet is stepped until the rest position is reached under the influence of the relay set U/R.

Finally the assessor is restored. The following circuit obtains: earth, contacts 149*y*2, 147*h*, 146*u*, winding of relay R, contact 158*c*, wiper *dg*6 in the rest position, wiper *dz*4 in the rest position, off normal contact 116*kk*, (closed when the two-motion switch is in the normal position) wiper *da*4 in the working position, magnet DA of the assessor, battery, and earth. When the assessor has reached the normal position under the influence of the relay set U/R this circuit is broken at wiper *da*4.

Through the release of relay C the other switching devices are also restored to normal. The locking circuit for relay M is broken at contact 8*c* and the locking circuit for relays S1 and K at contact 31*c*. Similarly at contact 8*c* the locking circuit for relays Q and T is broken, provided these have been energized. The locking circuit for relay P is broken at contact 109*k*. At the same time, at this contact, the locking circuit for relay G is broken. After relay P has released the locking circuit of relay F is broken at contact 2*p*.

*The calling subscriber hangs up during metering*

In the event of the calling subscriber replacing his receiver when a metering impulse has just been produced by the relay chain Z, Y1–Y4, the transfer to rapid metering cannot take place before the termination of this metering impulse since the first impulse of the more rapid succession can only be transmitted when the first and last relays of the chain have released again. If, for example, during a call a train of six metering impulses is transmitted after the expiry of three minutes and the calling subscriber hangs up during the second of these, relay F energizes as already described by the application of battery potential to the upper speaking lead in the preceding connecting device. Relay F closes its contact 87*f* and thereby prepares a circuit for relay S1 (winding I) and for relay Y1 (winding II). These relays cannot energize, however, because contact 88*y*3 of relay Y3 which only energizes, however, in the case of metering during a call, is opened. This releases when after relay Y4 has energized the circuit for relay Z is broken by the opening of contact 130*y*4 and the locking circuit for relay Y4 is broken by contact 89*da*. When the second metering impulse is terminated, that is, when relay Y4 has released on account of the short-circuit established at contact 99*y*2 the assessor magnet energizes over contact 144*y*4

so that now relays S1 and Y1 become energized when contact 89*da* closes and thus commences the first impulse of the more rapid succession. The further operations then take place in the manner described above.

What is claimed is:

1. In a telephone system, lines, means including a trunk line for establishing a connection between different ones of said lines, a metering impulse transmitting device, means responsive to completion of said connection for operating said device to transmit predetermined metering impulses thereover, means in said device operated on termination of said completed connection to cause a more rapid transmission of metering impulses yet to be transmitted.

2. A telephone system as claimed in claim 1, having a plurality of relays all of which or certain of which operate dependent on said last-named means for transmitting said impulses over said trunk line.

3. In a telephone system, lines, means including a trunk line for extending a connection between different ones of said lines, a metering impulse transmitting device, means responsive to completion of said connection for operating said device to transmit predetermined impulses over the trunk line, said impulses being transmitted during a completed connection by a gradual increase and decrease of metering potential, and means operated on termination of said completed connection for completing the transmission of metering impulses by interruption of direct metering potential.

4. A telephone system as claimed in claim 3, including an impulse transmitting circuit in said device having a series of inductances controlled during a completed connection for causing said potential variation.

5. In a telephone system, lines, means including a trunk line for extending a connection between different ones of said lines, a metering impulse transmitting device, an impulse transmitting circuit in said device including a series of inductances and a group of relays associated therewith, means responsive to completion of said connection for causing the application of metering potential through said transmitting circuit to said trunk line, and for causing the cyclic operation of the relays of said group successively for transmitting impulses over said trunk line by varying the value of said series of inductances and thus gradually increasing and decreasing the metering potential.

6. A telephone system as claimed in claim 5, wherein means is operated on termination of a completed connection for completing the transmission of metering impulses with only certain of the relays of said group effective.

7. A telephone system as claimed in claim 5, wherein means is operated on termination of a completed connection for disconnecting said series of inductances and rapidly completing the transmission of impulses over said trunk.

8. In a communication system, lines, means including a trunk line for establishing a connection between different ones of said lines, a metering impulse transmitting device, means responsive to completion of said connection for operating said device to transmit metering impulses thereover, means in said device operated on termination of said completed connection to cause a change in the speed of transmission of metering impulses yet to be transmitted.

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